Irrigation Water Budget

ESHMC Meeting

March 31, 2009

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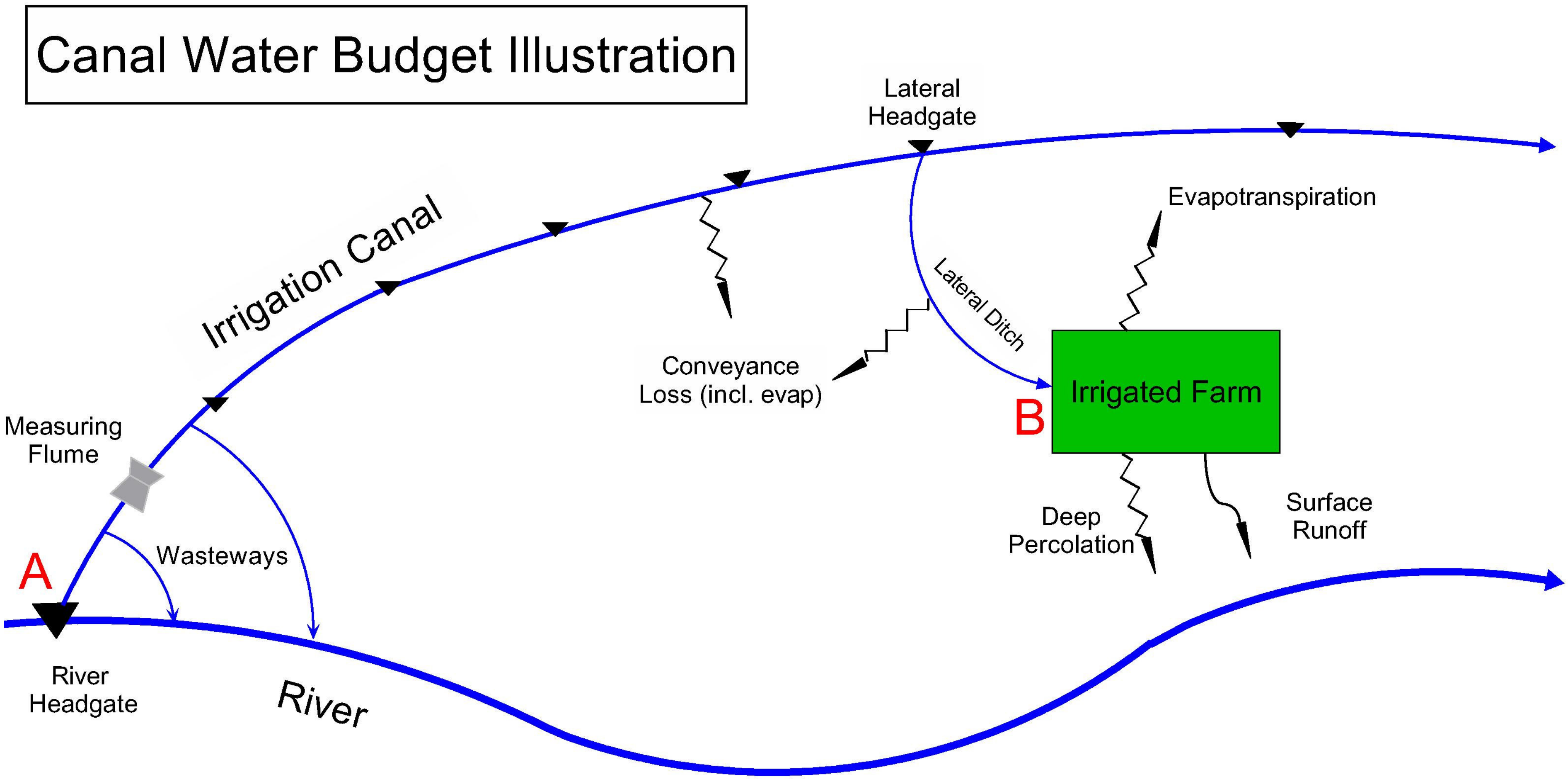
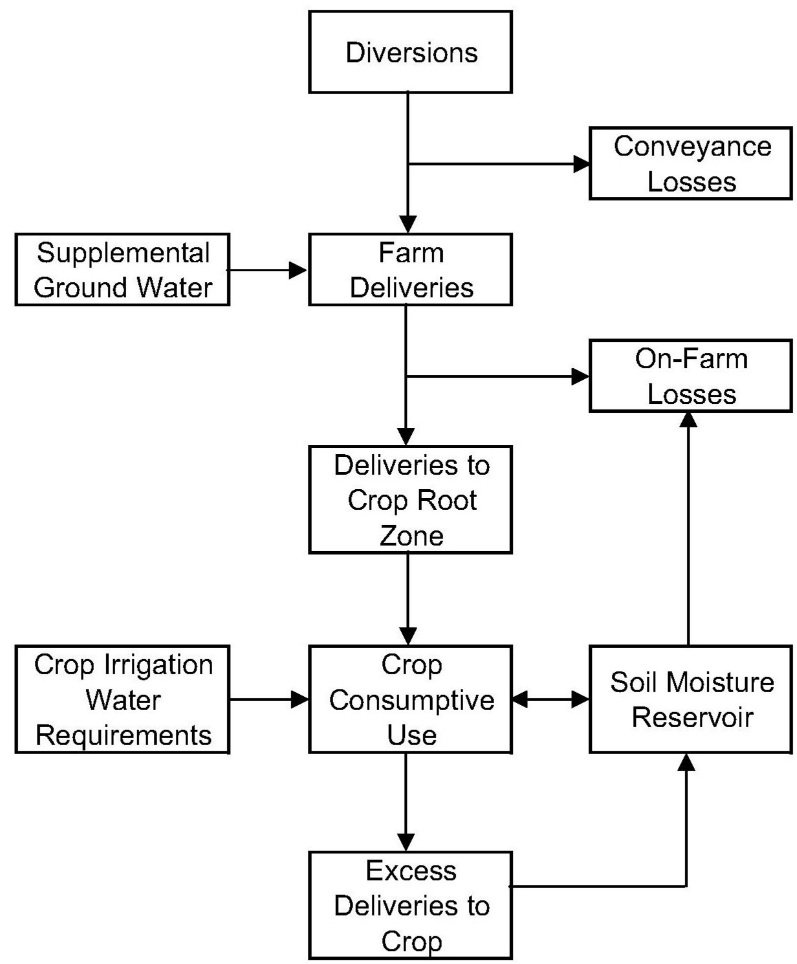


<u>Notes:</u>
Conveyance Efficiency - Measure of the water lost between A and B.
Farm Efficiency - Represents the amount of water at B that becomes available to the crop.

Typical Irrigation Water Budget Analysis



Irrigation Water Budget Issues

- Data limitations
- Seasonal or monthly analysis
- Irrigation water budget components
- ESPAM 1.1 return flows
- Conveyance losses
- On-farm water budget methods
- Soil moisture storage
- Deep percolation and surface runoff
- Effort to modify recharge tool

Data Limitations

- Water Budget Data
  - Diversions
  - Irrigated Area
  - Crop data
  - ET
  - Precipitation
- Spatial resolution
  - Typically no better than system wide for each SW or GW entity
  - Remember that many entities have been combined
- Temporal Resolution
  - Monthly for most data
  - Exceptions
    - Crop data

Seasonal or Monthly Analysis?

- Seasonal
  - Used in ESPAM 1.1
  - Implies diversions during any time during the irrigation season can meet demands at any time
  - May understate losses/recharge
  - Need to allocate seasonal recharge to monthly stress periods

- Monthly
  - Consistent with proposed monthly stress periods
  - Avoids time-shifting of supply and demand
  - Monthly data are generally available

Irrigation Water Budget Components

- Conveyance losses
  - Wasteway discharges/spills
  - Unused flow from the end of the canal
  - Canal seepage

- On-Farm Budget
  - Farm deliveries
  - Precipitation
  - ET
  - Deep percolation
  - Surface runoff
  - Soil moisture storage

ESPAM 1.1 Return Flows

- Based on return flow percentages applied to diversions
- Assumed to represent surface returns to Snake River
- Return flows are actually comprised of:
  - Canal wasteway discharges
  - Flow out the end of the canal
  - Surface runoff from applied irrigation water
  - Deep percolation that surfaces in drains
  - Precipitation runoff and natural tributary inflow
- Return flows do not include diffuse surface returns (i.e. not measured)

ESPAM 1.1 Return Flows

- Can a more explicit irrigation water budget analysis help with the “big mountain – little mountain” problem in the ESPAM 1.1 calibration?

- Consider how Return Flows fit with:
  - Conveyance losses
  - On-farm losses

- Need to avoid double counting irrigation losses

Conveyance Losses

- Conveyance losses = Waste/Spills + Seepage loss
- Waste/Spills
  - Represented by prior estimates of return flows?
- Seepage Loss
  - Bryce reports that we will have estimates of seepage losses for each ESPAM surface water user group

On-Farm Water Budget Methods

- ESPAM 1.1 Method
  - Recharge = Diversions – Canal Seepage* - Returns – ET
  - All farm deliveries can be consumed under water short conditions
  - Implies farm irrigation efficiency up to 100%
  - * canal seepage was only estimated for 3 users

- Maximum Farm Efficiency Method
  - Limits on-farm efficiency to user specified amount
  - Maximum efficiency can vary by application method

- Martin-Supalla Method (and other methods)
  - Bryce to discuss

Maximum Farm Efficiency Method

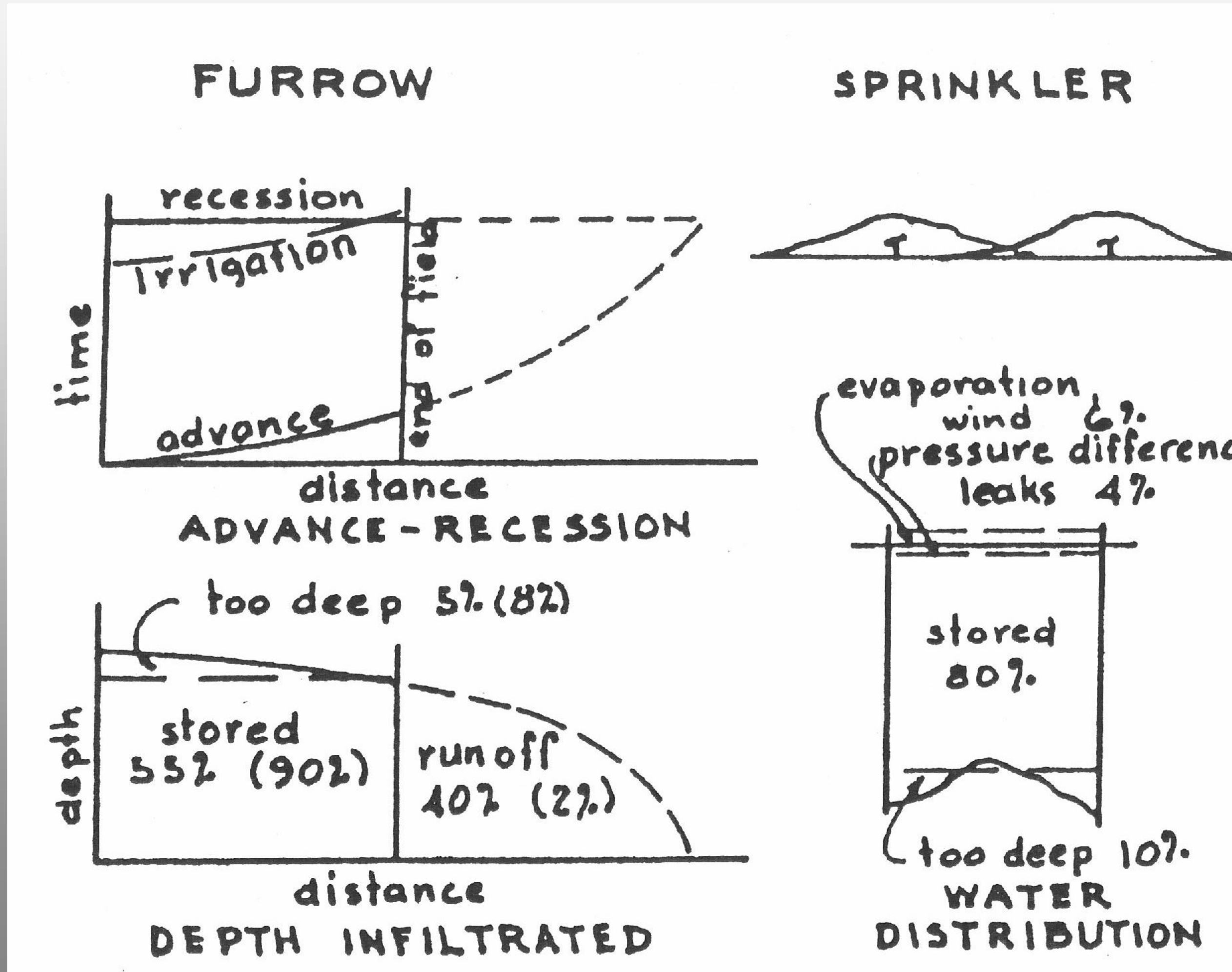
- Assume that in situations of limited water supply, farmers will irrigate their high value annual crops relatively well, and under-irrigate or not irrigate their lower value perennial crops

- Except in limited deficit irrigation circumstances, there are on-farm loss in surface water irrigation to:
  - Deep percolation
  - Surface runoff

Maximum Farm Efficiency Method

- Illustration of on-farm losses

(from Merriam, John L., “Efficient Irrigation,” California Polytechnic State University (1977)



Maximum Farm Efficiency Method

- Maximum farm irrigation efficiency varies by application method

- Sterling, R. and W.H. Neibling, Final Report of the Water Conservation Task Force. IDWR, 1994

Table 3. Typical irrigation system application efficiencies for surface and sprinkler irrigation systems.

	Application efficiency, %	Water required to put 1 inch in crop-root zone
Surface systems		
Furrow	35-60	1.7-2.8
Corrugate	30-55	1.8-3.3
Border, level	60-75	1.3-1.7
Border, graded	55-75	1.3-1.8
Flood, wild	15-35	2.8-6.7
Surge	50-55	1.8-2.0
Cablegation	50-55	1.8-2.0
Sprinkler systems		
Stationary lateral (wheel- or hand-move)	60-75	1.3-1.7
Solid-set lateral	60-85	1.2-1.7
Traveling big gun	55-67	1.5-1.8
Stationary big gun	50-60	1.7-2.0
Center-pivot lateral	70-85	1.2-1.4
Moving lateral (linear)	80-87	1.1-1.2

Maximum Farm Efficiency Method

- Water short conditions
  - On-farm loss computed based on (1-max farm efficiency)
  - Loss is split between:
    - Deep percolation
    - Surface runoff
  - Typically more deep percolation than surface runoff

- Water long conditions
  - All water applied in excess of the crop needs is lost to:
    - Deep percolation
    - Surface runoff
  - % to surface runoff typically increases in water long conditions

Maximum Farm Efficiency Method

Recharge = Initial recharge + recharge from excess application

$$\text{Recharge} = (1 - \text{OFE}) \times \text{Dh} \times \text{DPin} + \text{Max}(\text{Peff} + \text{OFE} \times \text{Dh} - \text{ET} \times \text{A}, 0) \times \text{DPex}$$

where

- Peff = effective precipitation
- OFE = maximum on-farm efficiency
- Dh = farm headgate delivery
- A = ET adjustment factor
- DPin = portion of initial loss to deep percolation
- DPex = portion of excess delivery to deep percolation

- *The above equation does not include simulation of a soil moisture reservoir*

Proposed Alternative Equation for On-Farm Irrigation Recharge (Monthly) (1)

$$\textbf{Recharge} = \underbrace{(1 - OFE) \times Dh \times DPin}_{\text{Initial Deep Percolation}} + \underbrace{\max(Peff + OFE \times Dh - ET \times A,\ 0) \times DPex}_{\text{Excess Deep Percolation}}$$

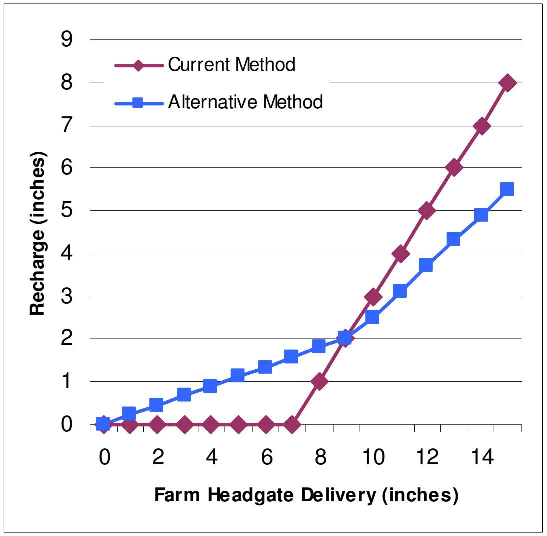
Open Spreadsheet

where

		Assumed Values	Comment
Peff =	effective precipitation (inches)	1.0	varies each month
OFE =	on-farm irrigation efficiency (decimal)	0.75	varies by user depending on irr applic method
Dh =	farm headgate delivery	**variable**	diversions minus conveyance loss and returns
ET =	crop ET (potential) (inches)	8.0	traditional calculation of potential ET
A =	ET adjustment factor (decimal)	1.00	adjustment for sprinkler and other losses
DPin =	Initial portion of irr loss to deep percolation (decimal)	0.90	portion of irrigation "inefficiency" to deep perc; remainder to surface runoff.
DPex =	portion of excess irr applic to deep percolation (decimal)	0.50	portion of application in excess of crop consumption to deep perc; remainder to surface runoff

Example Calculation of Monthly Recharge
for Varying Monthly Farm Headgate Delivery Amounts
(inches/month)

	Alternative Method					**ESPAM 1.1(2,3) Method**
Farm HG Delivery (inches)	Recharge (inches) Initial	Recharge (inches) Excess	Recharge (inches) Total	Surface Runoff (inches)	Total Loss (inches)	Recharge (inches)
0	0.00	0.00	0.00	0.00	0.00	0.00
1	0.23	0.00	0.23	0.03	0.25	0.00
2	0.45	0.00	0.45	0.05	0.50	0.00
3	0.68	0.00	0.68	0.08	0.75	0.00
4	0.90	0.00	0.90	0.10	1.00	0.00
5	1.13	0.00	1.13	0.13	1.25	0.00
6	1.35	0.00	1.35	0.15	1.50	0.00
7	1.58	0.00	1.58	0.18	1.75	0.00
8	1.80	0.00	1.80	0.20	2.00	1.00
9	2.03	0.00	2.03	0.23	2.25	2.00
10	2.25	0.25	2.50	0.50	3.00	3.00
11	2.48	0.63	3.10	0.90	4.00	4.00
12	2.70	1.00	3.70	1.30	5.00	5.00
13	2.93	1.38	4.30	1.70	6.00	6.00
14	3.15	1.75	4.90	2.10	7.00	7.00
15	3.38	2.13	5.50	2.50	8.00	8.00



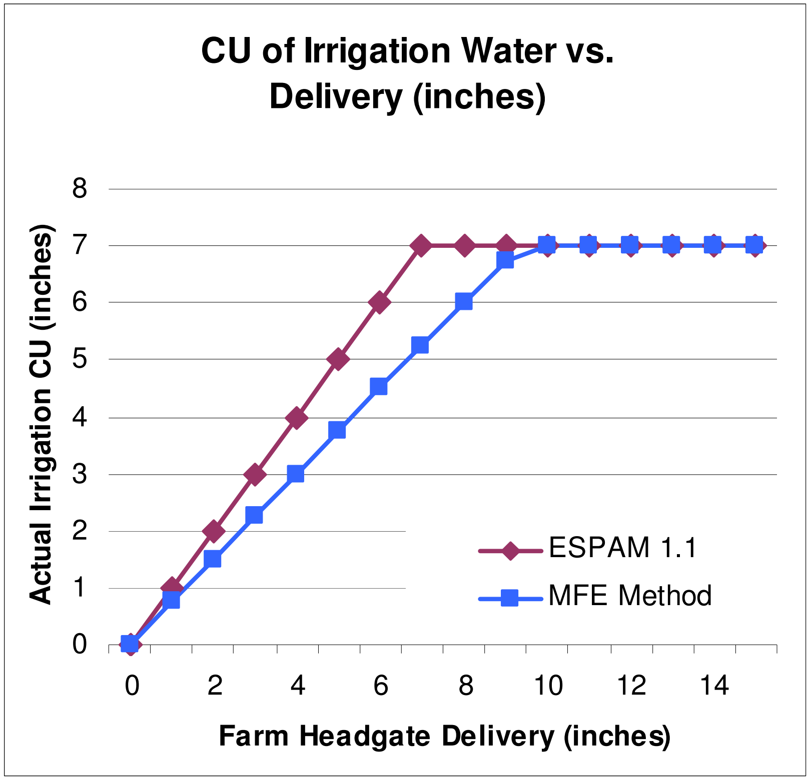
Notes

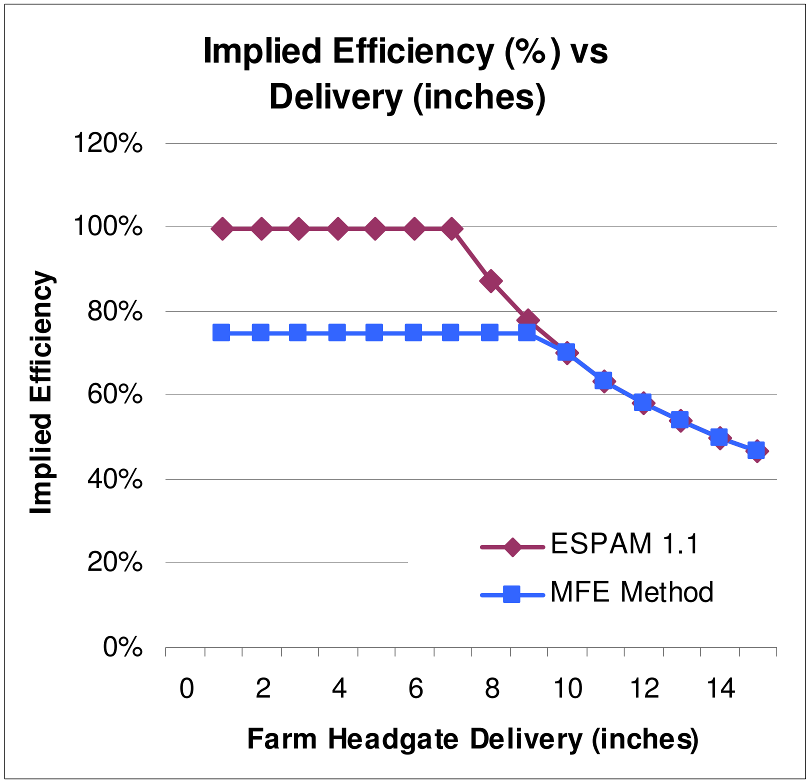
(1) Neither method considers the effect of changes in soil moisture storage on the timing and amount of recharge.

(2) **Current Method: Recharge = max(Dh + P - ET x A), 0)**

(3) The current method uses the total precipitation, not effective precipitation.
In this example, total precipitation is assumed to be the same as effective precipitation

Comparison of ESPAM 1.1 Method and Maximum Farm Efficiency Method





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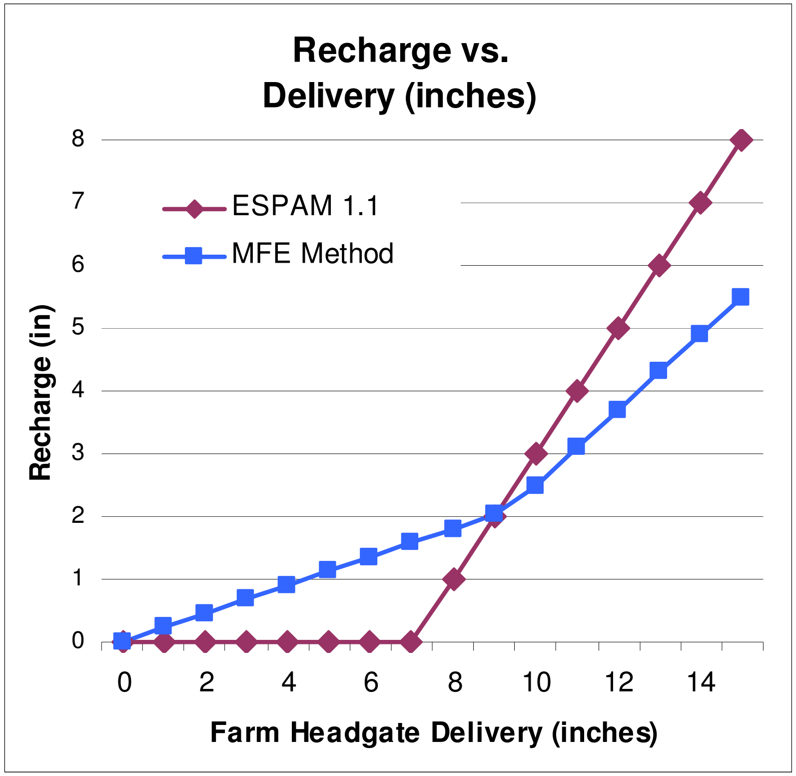

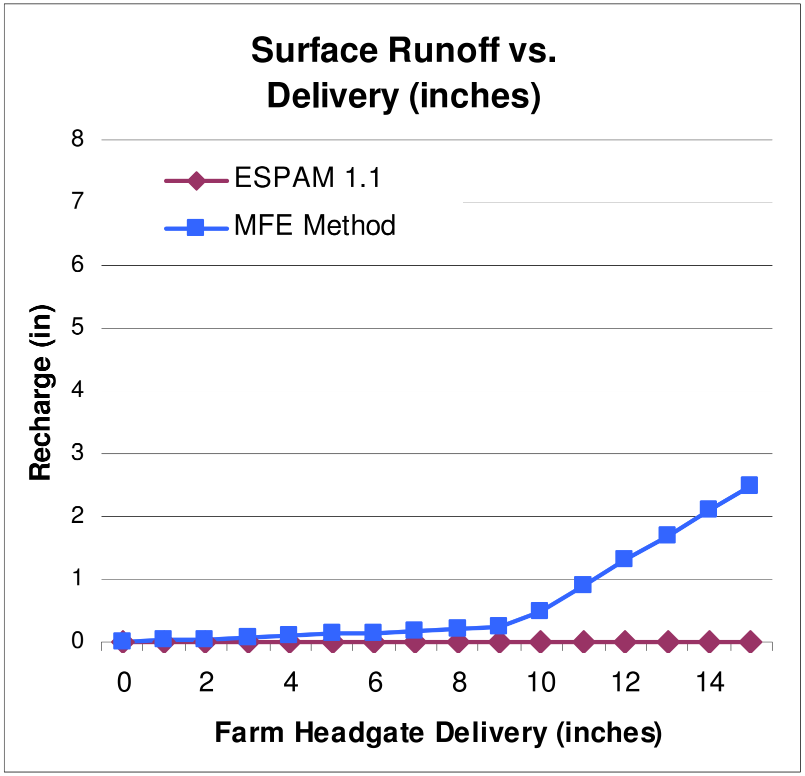

Soil Moisture Storage

- Should the farm budget include simulation of a soil moisture reservoir?
- Soil in the root zone can hold water in excess of immediate crop needs for later use
- Can affect the timing and amount of recharge.
- Available water holding capacity in the root zone is approximately 6 inches
  - Depending on soil type
  - Root zone thickness
- What about the vadose zone below the root zone?

Soil Moisture Storage

- Simulation is relatively simple
- Model like a simple reservoir
  - Excess deliveries go into storage (up to capacity)
  - Water released from storage to meet crop requirements in excess of deliveries.

Deep Percolation vs. Surface Runoff

- Irrigation losses occur as surface runoff and deep percolation
- ESPAM 1.1
  - Return flows assumed to include all surface runoff
  - On-farm losses go to deep percolation (aquifer recharge)
- Alternative Method
  - Split irrigation losses between SRO and DP
  - SRO/DP split can vary based on application method and other factors
  - SRO can be intercepted by down-gradient canals
    - Reflected in conveyance loss assumption (net loss)
  - Don't double count SRO to extent it is included in return flows

Effort to Modify Recharge Tool

- ????